BC hydro

Justification Report

Fraser Valley System Reinforcement Project

June 1991

Report No. SP 9105

proud of our Service

Canadian Cataloguing in Publication Data
Main entry under title:
Fraser Valley System Reinforcement Project
justification report

"Report no. SP 9105".
ISBN 0-7726-1367-2

1. Electric substations - British Columbia 2. Electric power transmission - British Columbia. I. B.C. Hydro

TK1751.F72 1991 621.31'26 C91-092205-5

92-00222/

B.C. HYDRO

FRASER VALLEY SYSTEM REINFORCEMENT PROJECT

Justification Report

Prepared by: _____
J.W. Kwan, P. Eng

Reviewed by: _____
A. Langmuir, P. Eng
Manager, Area Transmission Planning Department

Approved by: _____
B.G. Prior, P.Eng
Manager, System Planning Division

June 1991

SYSTEM PLANNING DIVISION

Report No. SP 9105 File:CBN-1540

1. INTRODUCTION 1

2. ELECTRICAL TRANSMISSION SYSTEM 1

2.A What is an Electrical Transmission System 1
2.B Supply of Electricity to South Central and East Fraser Valley 1
2.C Reliability of Supply 2

3. SUBSTATION LOAD AND THE LOAD FORECAST 3

4. LOAD SUPPLY LIMITATIONS 4

5. REINFORCEMENT ALTERNATIVES 5

5.A STATION REINFORCEMENT ALTERNATIVES 5
5.B NON-STATION ALTERNATIVES 6
5.C IMPACT OF CONSERVATION 7

6. CONCLUSION 7

APPENDIX

A. ECONOMIC ANALYSIS
B. FIGURES

1. Introduction

As a result of continued growth in electricity demand in the south central Fraser Valley area, the transmission circuit that connects Bridge River Generating Station and Ingledow Substation via Rosedale can no longer provide a reliable supply to the distribution substations serving the south central and eastern parts of the Fraser Valley. The area under consideration is shown in Figure 1. It encompasses areas south of Fraser River (except the northern part of Langley) and east from 192 Street to the Fraser Canyon.

Based on the latest forecast of electricity demand for the Fraser Valley area, reinforcement to the Ingledow - Bridge River transmission system will be required by mid-nineteen nineties. Transmission reinforcement involves the building of 500/230 kV transformation facilities at an existing 230 kV substation along the transmission circuit (McLellan, Clayburn or Atchelitz Substation) and connecting the substation to one of the adjacent 500 kV circuits in the Fraser Valley. Based on system planning technical criteria, Clayburn Substation appears to be the most suitable location for the reinforcement.

2. Electrical Transmission System - Supply to South Central and Eastern Fraser Valley

(A) What is an Electrical Transmission System

An electrical transmission system is a complex network of transmission lines and substations that delivers electricity from the generating plants to the consumers.

Figure 2 is a schematic drawing showing the basic elements of a simple electrical system. High voltage transmission lines (usually 500 kV) take the electricity from generating plants to large central substations at which the transmission voltage is lowered. Medium voltage transmission lines (voltage ranges from 60 kV to 360 kV) take the electricity from the large central substations to distribution substations at which the voltage is further lowered. Finally distribution lines (voltage ranges from 4 kV to 25 kV) take the electricity from the distribution substation to small local distribution transformers (usually mounted on poles). At these distribution transformers the voltage is finally lowered to the common household level (120 V and 240 V). Low voltage wires take the electricity from the distribution transformers to the individual residential, commercial and small industrial customers where electricity is consumed.

(B) Supply of Electricity to South Central and East Fraser Valley

The electrical transmission system in the south central and eastern parts of the Fraser Valley is drawn schematically in Figure 1. For demonstration purposes, Figure 1 also shows how an individual customer in South Langley, Aldergrove and Chilliwack area is connected by distribution circuit from the supplying substation. The electrical system in Figure 1 can be represented by a block diagram as shown in Figure 3. The block diagram shows that the electricity consumed in the south central and eastern parts of Fraser Valley

comes from two transmission sources, and is supplemented with local generation at Wahleach Generating Station. The two transmission sources are:

1. From Bridge River Generating plant to Rosedale Substation to serve from the north.

2. From Ingledow Substation to McLellan Substation to serve from the west. Ingledow Substation is one of the principal transmission substations for the Lower Mainland. It receives power from large generating plants in the Interior via 500 kV transmission lines. Power is then transmitted from Ingledow Substation to Metro and Fraser Valley areas at lower transmission voltages, namely 60 kV and 230 kV.

Figure 3 also shows the relative magnitude of area need during the highest demand for electricity in the winter of 1990 and the flow of electricity from the transmission sources into the area to satisfy the total area demand (actual load plus transmission line losses). In 1990 the electrical demand of the south central and east Fraser Valley area was supplied roughly in the following manner: -- Bridge River Generating Plant 66%, Wahleach Generating Plant 16% and Ingledow Substation 18%. Langley and Matsqui are among the fastest growing areas in the Lower Mainland. As the demand for electricity in these area increases in the future, because of their close proximity to Ingledow Substation, the contribution from Ingledow Substation will also increase.

(C) Reliability of Supply

Reliability of supply is a measure of the ability of the electrical system to adequately supply the electrical requirements of the customers, referred to as load. When the load is adequately served, the supply source is reliable. Customers will experience a supply problem, that is an outage, whenever their supply source is interrupted or the supply voltage is outside an acceptable limit. It is impractical to design a system that is completely free of outages (100% reliable). The system is designed to be reliable, cost effective and responsive to the changing demands and values of our customers.

When the supply source to the load is interrupted, either momentarily or for a longer period of time, the load will be lost. When the supply voltage is outside the accepted limit, customers' equipment will be operating outside the designed condition. Some examples of the results of supply voltage higher than the acceptable limit are equipment insulation breakdown and reduction in lamp and TV tube life. The results of supply voltage lower than the acceptable limit are overheating of motors, low output from lamps and malfunction of electronic equipment.

The outages experienced by customers can be grouped into two categories, namely distribution related outages and transmission related outages. Customers will experience a distribution related outage when the distribution line which provides power to their premises or the distribution circuit which provides power to their neighborhood is out-of-service. These type of outages are usually the results of falling trees or branches on the

distribution circuit wires. Customers will experience a transmission related outage when the distribution substation which services the area has an outage due to station equipment failure or failure(s) of transmission line and/or station equipment from which they are supplied.

As an example(see Figure 1).

Distribution related outages:-
Some Aldergrove customers and their neighbors will be without power when local distribution line A-B is disconnected. These same customers and all the customers in Aldergrove will be without power when the distribution circuit B-C is out-of-service.

Transmission related outages:-
If Clayburn Substation is out-of-service, customers in Aldergrove and most parts of Matsqui will be without power. If the transmission circuit between Ingledow Substation and McLellan Substation is out-of-service, electricity demand of the area will have to be supplied from Bridge River supplemented with generation at Wahleach. Under this condition, if demand exceeds the capability of the Bridge River to Rosedale transmission circuit , the transmission voltage in the area would be depressed. This could lead to a wide spread outage throughout south central and eastern parts of Fraser Valley.

Since failure of transmission equipment can affect a large number of customers, the transmission system is usually planned so that no disruption of service would result if one component in the transmission system is out-of-service.

3. Substation Load and the Load Forecast

The combined electricity demand on a substation is known as the station load. B.C. Hydro annually prepares a 10 year load forecast for each of the substations in the entire system. Electric system plans are then prepared based on this load forecast, taking into account the long lead time required for the purchase of materials and the installation of new transmission and station equipment.

The substation load forecast is prepared based on the global economic growth of the province as well as the local growth of the district. It takes into account factors such as municipal zoning, residential and industrial development plans, building permits, population growth estimates and Power Smart initiatives. The substation load forecast is updated annually using the latest information from the municipality, the actual recorded maximum load demand of the substation, and the effect of temperature on electricity consumption.

Figure 4 is a bar chart showing the actual (1980 -1990) and the projected (1991 - 1997) load in the different areas of south central Fraser Valley and Fraser Canyon. It also shows the average load growth for the areas during the two periods.

4. Load Supply Limitations

South central and eastern Fraser Valley has three supply sources, namely, two transmission sources (Bridge River Generating Station and Ingledow Substation), and one generation source at Wahleach (see Figure 3). If any one of these sources is out-of-service the other two sources will have to supply the total area demand. As mentioned in section 2(C), the transmission system is planned to withstand the outage of one of its components, therefore, the outage of a supply source to south central and eastern Fraser Valley should not disrupt service to the customers.

(A) If the transmission circuit between Ingledow Substation and McLellan Substation is out-of-service, Bridge River Generating Station and Wahleach Generating Station will be the only supply sources. The combined capacity of Bridge River transmission line and Wahleach generation is about 375 MVA, and is based on their ability to provide an acceptable voltage to customers in south central and eastern Fraser Valley. If the load demand in the area exceeds this supply capability, reinforcement of the transmission system will be required. Based on the latest load forecast, the anticipated 1994 area load demand will exceed the supply capability, that is reinforcement to the transmission system will be required prior to the 1994 winter peak load period.

(B) If the Bridge River transmission circuit is out-of-service, Ingledow Substation and Wahleach Generating Station will become the only supply sources. In this scenario no major supply problem is anticipated for the next 10 years. Continued load growth in the south central Fraser Valley area will make the task of maintaining acceptable supply voltage to customers in the Fraser Canyon increasingly more difficult. This is a local problem, and in the short term, can be solved with equipment additions in the various distribution substations in the Fraser Canyon area.

(C) Even though the maximum output from Wahleach Generating Station is only 60 MW (33 MW on the average) the generation is vital to the supply of power to south central and eastern Fraser Valley areas. Outage of Wahleach Generating Station alone will not create a supply problem as sources from Bridge River and Ingledow will be able to supply the total area demand. However, if the generating unit is not available for service during the outage of either of the two transmission sources into the area, then wide spread outage could result.

Reliability of the Wahleach generating unit is not high. For the past 12 years (from 1977 to 1988) Wahleach Generating Station was available, on the average, 76% of the time. In 1989 the generating station was taken out of service for 9 months as a result of cracks in the intake tunnel caused by bedrock instability. The cracks are

now repaired and the generating station has been put back into service. B.C. Hydro is continuing a monitoring program on the stability of the area.

5. Reinforcement Alternatives

(A) Station Reinforcement Alternatives

The most effective method to reinforce the Fraser Valley 230 kV system is to introduce a third source onto the 230 kV transmission system from the adjacent 500 kV system. It involves the building of 500/230 kV transformation facilities at an existing 230 kV substation along the transmission circuit (McLellan, Clayburn or Atchelitz Substation) and connecting the substation to one of the adjacent existing 500 kV circuits in the Fraser Valley. There are three station reinforcement alternatives, they are:

(i) Build a 500/230 kV substation at Atchelitz Substation.
(ii) Build a 500/230 kV substation at Clayburn Substation.
(iii) Build a 500/230 kV substation at McLellan Substation.

An economic analysis for the three station alternatives is shown in Appendix A.

(i) Atchelitz Alternative

A 500/230 kV substation can be built at the existing Atcheltiz Substation site for a direct cost of $20,804,000. At this time, B.C. Hydro does not own sufficient land at Atchelitz Substation for the proposed 500/230 kV expansion. The additional land needed for substation expansion is privately held and would have to be purchased and removed from the agriculture land reserve.

Atchelitz Substation is the supply source to the 69 kV distribution substations in Abbotsford, Chilliwack and Kent areas. However, in the future, loads in the Abbotsford area will be transferred and supplied from Clayburn Substation to improve the supply reliability and to reduce the transmission line losses. This will reduce the total load demand on Atchelitz Substation.

Population and load growth in the central Fraser Valley are concentrated around Langley (near McLellan Substation) and Abbotsford/Matsqui (near Clayburn Substation) area. Atchelitz Substation would not be close to load centers and would, therefore, incur additional transmission losses when compared with Clayburn Alternative or McLellan Alternative. The additional transmission losses amounts to $272,000 annually.

Atchelitz Substation could meet the anticipated electricity demand for about twenty years, beyond that time, reinforcement of the system at Clayburn or McLellan Substation will be required.

(ii) Clayburn Alternative

A 500/230 kV substation can be built at the existing Clayburn Substation site for a direct cost of $21,952,000. When the existing Clayburn 230/25 kV Substation was developed in the early 1980s, B.C. Hydro acquired sufficient property and transmission line right-of-way at Clayburn Substation for 500 kV expansion. No additional land will be required for the proposed station expansion.

Clayburn Alternative is the least cost alternative in the long term. As shown in Figure 3, Clayburn Substation is located in an area of high population and load growth, reinforcement at Clayburn Substation would save on transmission losses and meet the anticipated electricity demand for over thirty years.

In addition to supplying Abbotsford/Matsqui area, Clayburn Alternative would also provide strategic support to McLellan Substation and the eastern part of Fraser Valley. In future, it could be a supply source for the Mission area.

(iii) McLellan Alternative

A 500/230 kV substation can be built at the existing McLellan Substation site for a direct cost of $28,245,000. B.C. Hydro has sufficient property and transmission line right-of-way at McLellan to accommodate the proposed 500 kV expansion. However, usable space is limited and as a result, compact substation design would be required. This substantially increases the capital cost of the project.

McLellan Substation is located in an area of high growth, reinforcement at McLellan will save on transmission losses. In fact, the transmission losses for Clayburn Alternative and McLellan Alternative are almost the same and are less than Atchelitz Alternative.

McLellan Substation is close to Ingledow Substation As shown in Figure 3, the installation of a 500/230 kV transformation at McLellan Substation is to effectively move the transmission source into the south central and eastern Fraser Valley area eastward from Ingledow Substation to McLellan Substation. As a result, reinforcement at McLellan Substation is less effective in meeting the long term load growth and would only meet the anticipated area electricity demand for about fifteen years. After that time, reinforcement at Clayburn Substation will be required.

(B) Non-station Alternatives

In addition to the three station reinforcement alternatives, other non-station reinforcement alternatives were investigated. These non-station reinforcement alternatives were

discarded because they are only short-term measures and were not cost effective. The options investigated were:

(i) Install a dynamic voltage device (Static Var compensator) at Clayburn Substation to remove the voltage imposed limitation on the Bridge River transmission circuit. However, this alternative can only support the anticipated load growth for about four years. Beyond this time frame additional reinforcement would be required. When compared with a 500/230 kV transformation, a Static Var compensator does not have the strength and flexibility and is significantly less reliable.

(ii) Install a series-capacitor station approximately mid-way between Bridge River and Rosedale to reduce the "electrical length" of the Bridge River transmission circuit. However, this alternative can only support the anticipated load growth for about five years. Beyond this time frame, additional reinforcement would be required. Also, it does not address the supply problem to Fraser Canyon.

(iii) Build a new 230 kV transmission circuit between Ingledow Substation and McLellan Substation. The effect of this alternative is similar to building a 500/230 kV substation at McLellan as it will make McLellan Substation a strong source without substantial improvement in the overall reliability of south central and eastern Fraser Valley. In addition to the relatively short-term benefit (15 years), this alternative would require acquisition of additional transmission line right-of-way and building a new transmission line through an area with increasing development density.

(C) Impact of Conservation

The impact of conservation was also investigated. No transmission reinforcement will be required if the total area electricity demand is within the capability of the Bridge River transmission system. Conservation and reduced load development will slow down the demand of electricity in the area and will therefore defer, but not eliminate, the need of transmission reinforcement. Since the lead time for building a 500/230 kV substation is at least 4 years, the conservation alternative would not influence the initiation of the project but it would have a significant impact on its completion date.

6. Conclusion

The demand for electricity in south central Fraser Valley is increasing rapidly. If this growth in demand is not slowed down by conservation and/or by reduced development, it is forecast that by 1994 the combined electricity demand in the area will exceed the capability of the Bridge River transmission circuit supplying the area.

Based on system planning technical evaluation, the preferred alternative to reinforce the Valley's transmission system is to install a 500/230 kV transformation at a site along the 230 kV transmission line. Clayburn Substation appears to the most suitable location for the 500/230 kV transformation.

APPENDIX A

Economic Analysis

(A) Stage Development

All three reinforcement alternatives under consideration involves the building of 500/230 kV transformation facilities at an existing 230 kV substation site in 1994. The three alternatives have different supply capabilities. The stage development for the three alternatives, over a 30 year study period, is as follow:

(1) Atchelitz Alternative

Build 500/230 kV transformation facilities at Atchelitz Substation in 1994. Reinforce the system at Clayburn or McLellan Substation in 2014.

(2) Clayburn Alternative

Build 500/230 kV transformation facilities at Clayburn Substation in 1994. This alternative will be able to supply the load demand for over thirty years. No additional 500/230 kV reinforcement will be required in the study period.

(3) McLellan Alternative

Build 500/230 kV transformation facilities at McLellan Substation in 1994. Reinforce the system at Clayburn in 2009.

(B) Summary of Costs (in 1990 dollars)

The project cost estimates for the three alternatives are summarized below:

Cost Component	Atchelitz Alt.	Clayburn Alt.	McLellan Alt.
Transmission	$ 2,004,000	$ 3,216,000	$ 3,245,000
Substation	18,800,000	18,736,000	25,000,000
Subtotal (direct)	$20,804,000	$21,952,000	$28,245,000
Inflation	3,012,000	3,223,000	4,168,000
Corporate Overhead	2,160,000	2,283,000	2,935,000
Interest During Construction	2,966,000	3,028,000	3,825,000
Total Project Cost	$28,942,000	$30,486,000	$39,173,000

The transmission losses for the Clayburn Alternative and McLellan Alternative are almost the same and are less than the Atchelitz Alternative. The additional transmission losses for the Atchelitz Alternative amounts to $272,000 annually. As shown in the Stage Development, by year 2014 Atchelitz Alternative will have reinforcement at either Clayburn or McLellan Substation, at that time the three reinforcement alternatives will have similar transmission losses.

Figure 5 shows the cumulated present-worth cash flows of the three alternatives for the study period. McLellan Alternative is the most expensive alternative. Atchelitz Alternative has the lowest capital cost. However, due to additional transmission losses and the required system reinforcement in the later part of the study period, Atchelitz Alternative is more expensive than Clayburn Alternative in the long term. The costs of additional transmission losses for the Atchelitz Alternative and the cumulated present-worth cash flow for the three alternatives are listed below.

	Atchelitz Alt.	Clayburn Alt.	McLellan Alt.
Annual Incremental Transmission Losses Over Clayburn Alternative	$272,000	----------	----------
Total cumulated 1990 present-worth cash flow for the study period (Discounted at 8%)	$22,685,000	$17,467,000	$27,160,000

LIST OF FIGURES

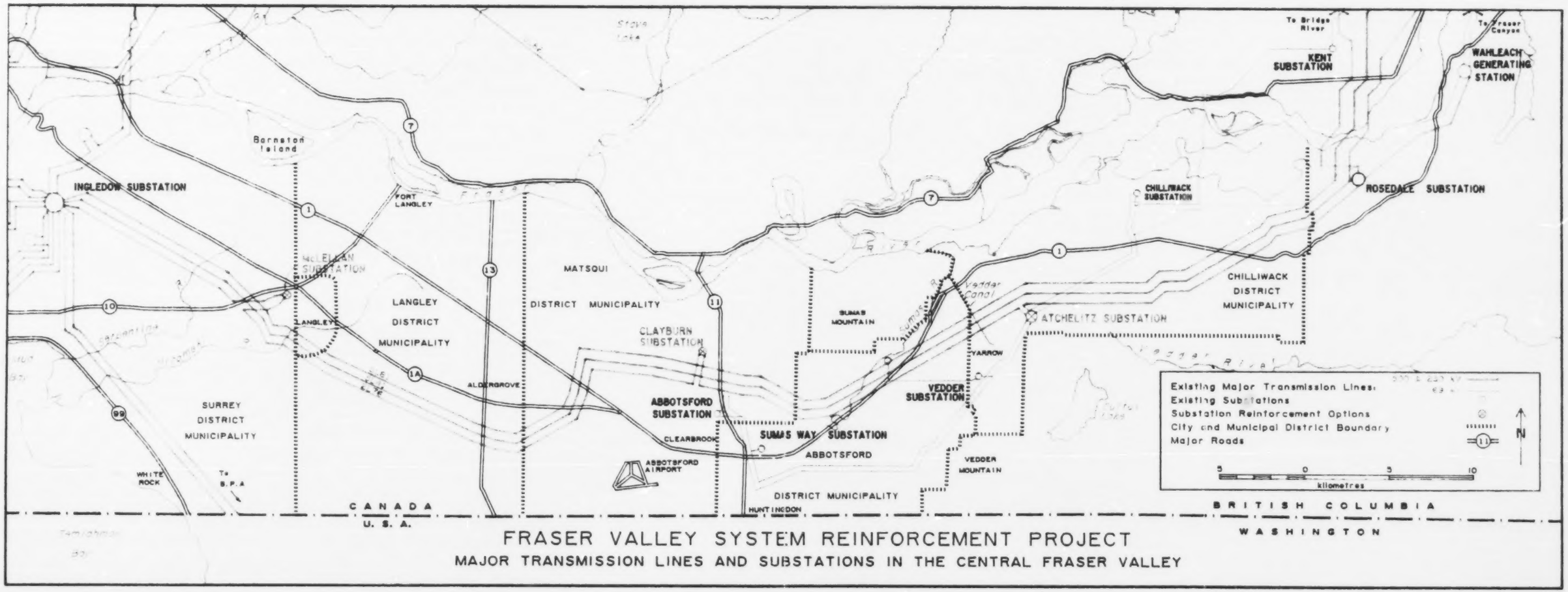
Figure 1 - Major transmission lines and substations in the central Fraser Valley

Figure 2 - Basic elements of an electrical system

Figure 3 - Block diagram representation of south central and eastern Fraser Valley

Figure 4 - South central and east Fraser Valley total load demand

Figure 5 - Fraser Valley system reinforcement, cumulated present-worth cash flow



FRASER VALLEY SYSTEM REINFORCEMENT PROJECT

MAJOR TRANSMISSION LINES AND SUBSTATIONS IN THE CENTRAL FRASER VALLEY

FIGURE 1

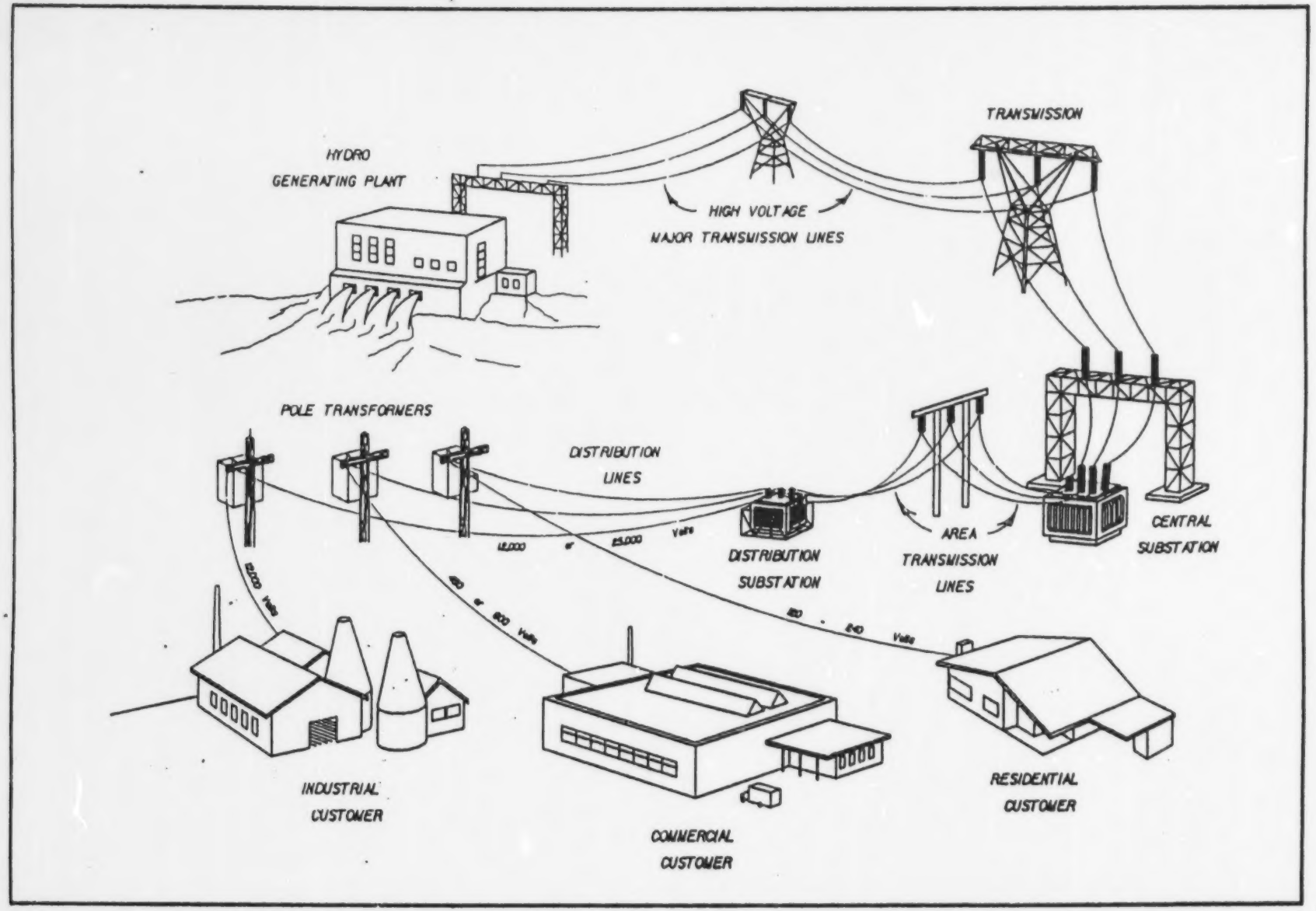
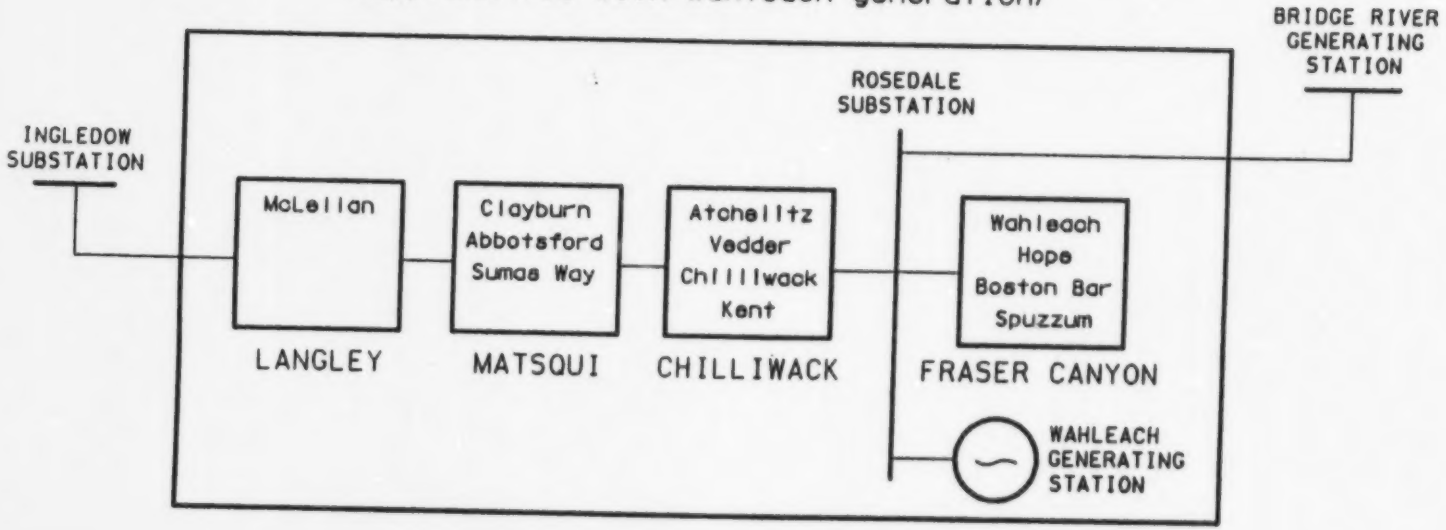


FIGURE 1 - BASIC ELEMENTS OF AN ELECTRICAL SYSTEM

Figure 3

BLOCK DIAGRAM REPRESENTATION of SOUTH CENTRAL AND EASTERN FRASER VALLEY

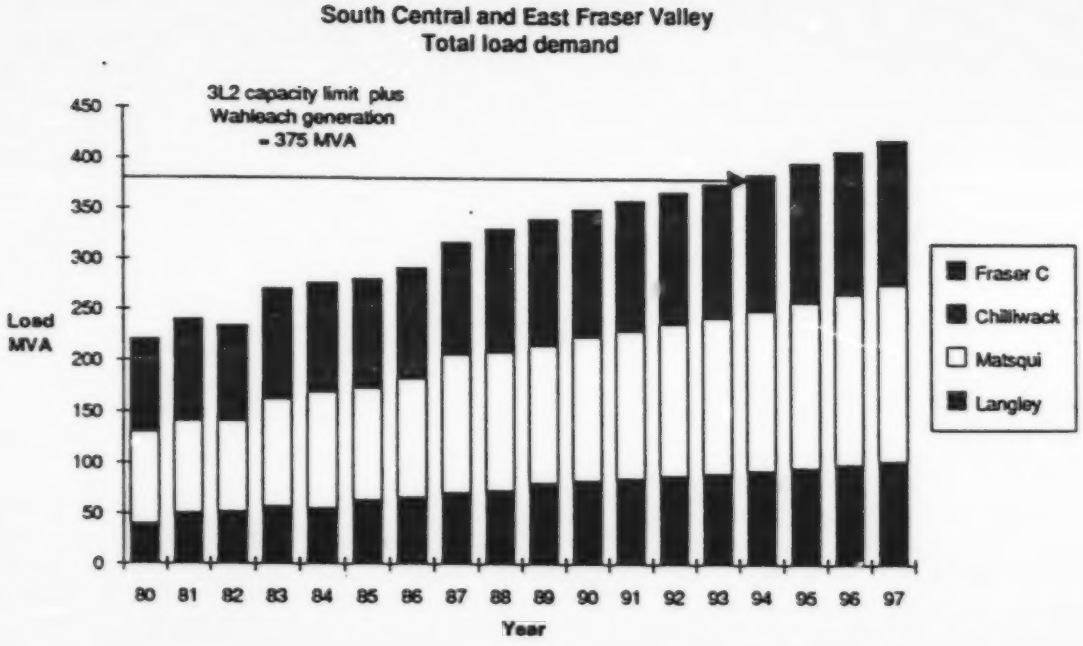
(Area supplied by two transmission sources supplemented with Wahleach generation)



	(Langley)		(Matsqui)		(Chilliwack)		(Fraser Canyon)		(Transmission Line Losses)		(Total)
1990 highest area load demand in MVA	83	+	140	+	100	+	26	+	16	=	365

	(Ingledow)		(Bridge River)			(Wahleach)		(Total)
Input from transmission sources and local operation in MVA	65	+	240	+		60	=	365

NOTE: 1 MVA = 1000 KVA
The load demand of a typical non-electrically heated home in the Fraser Valley is 3 KVA



A chart showing the actual (1980 - 1990) and projected (1991 - 1997) load in different areas of the Fraser Valley.

Substations included in these areas are:		average load growth per year (%)	
		1980-89	1990-97
Langley:-	McLellan	8.1	3.1
Matsqui:-	Clayburn, Abbotsford and Sumas Way	2.8	3.2
Chilliwack:-	Atchelitz, Vedder, Chilliwack and Hope	3.6	2.1
Fraser Canyon:-	Wahleach, Hope, Boston Bar and Spuzzum	3.9	0.5
	Total Area	4.9	2.7

Figure 4

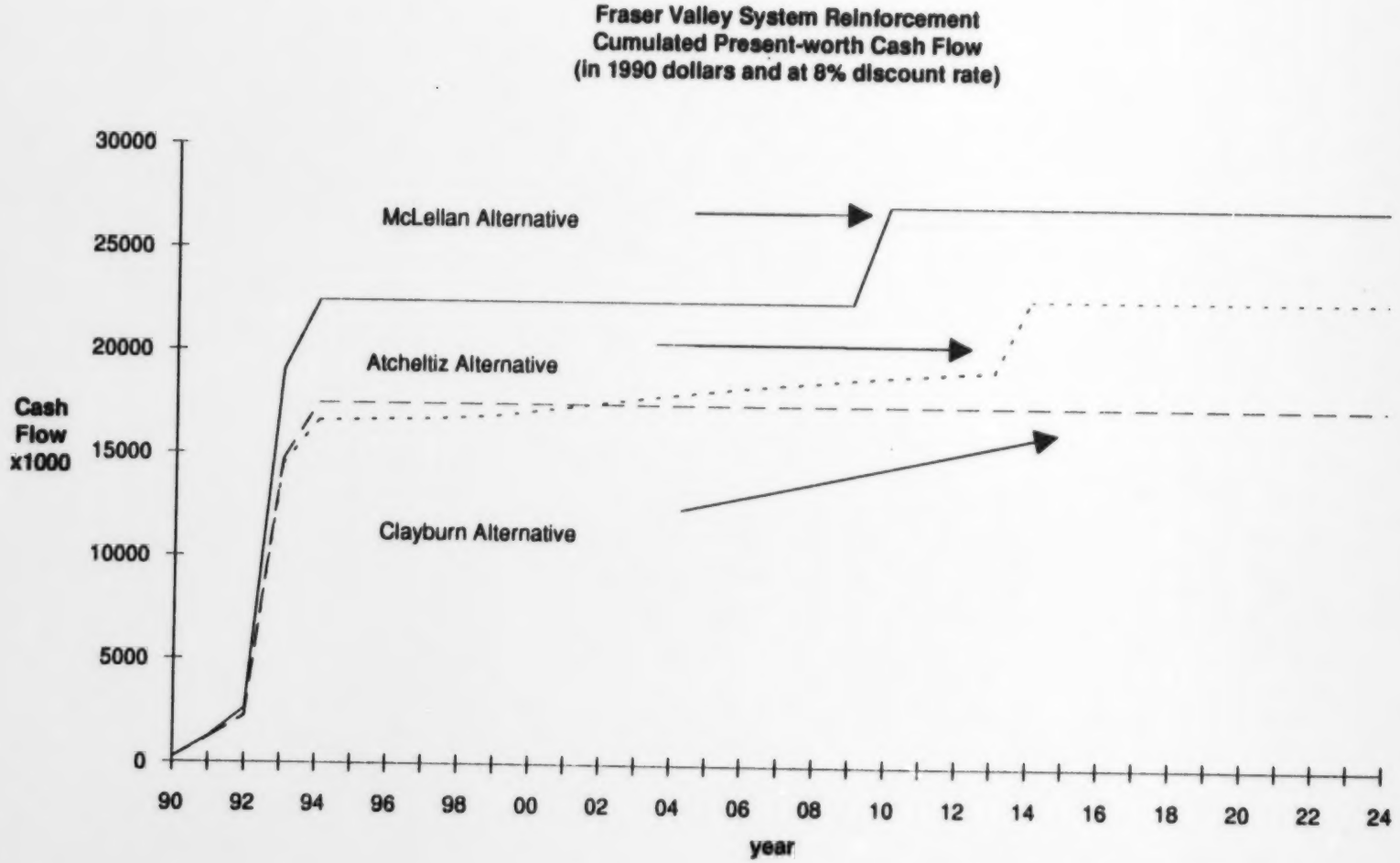

Fraser Valley System Reinforcement
Cumulated Present-worth Cash Flow
(in 1990 dollars and at 8% discount rate)
30000
25000
20000
15000
10000
5000
0
Cash Flow x1000
McLellan Alternative
Atcheltiz Alternative
Clayburn Alternative
90
92
94
96
98
00
02
04
06
08
10
12
14
16
18
20
22
24
year

Figure 5